EFFECT OF ALKALINE SOLUTION ON COMPRESSIVE STRENGTH OF CEMENT LATERIZED CUBE WITH DIFFERENT SOIL GRAINS SIZE

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ABSTRACT

There are many factors that can increase the compressive strength of cement laterized cube. For example, it can be affected by the influence of additives, mix ratio of materials, grains size of aggregates and many other factors. This paper report the effect of alkaline solution concentration on the compressive strength of cement laterized cube which made by different laterite soil grains size. Besides that, there were two curing method that has been carried out which were air curing method and also dry in oven method. This research is also with a view to recommending the production of blocks from cement laterized in supplementing sandcrete blocks in the building construction industry, especially for low cost or rural building. For sample preparations, the crushed laterite soil was sieved into three different grains sizes which are, 1.18mm, 600 micro and 150 micro sizes. Then, each soil sizes will be mixed with a mix ratio of 1:2:6 (cement: soil: sand). Sodium hydroxide, (NaOH) solution with concentration of 1, 2 and 3 molar will be added in the mix and then cast the cube samples for each curing method. The compressive strength of the cube samples were recorded at the age of 14 days and 28 days of curing. The effect and relationship between the soil grains size, alkaline solution concentration, and curing method can be seen clearly. It can be concluded that, for this soil sample and for the mix ratio of 1:2:6, only 1 mol of alkaline solution is recommended. Addition of higher concentration of alkaline solution will reduce the compressive strength of the cube. In term of grains size effect, control samples made from 600 micro sizes produce the highest average compressive strength which is 3.602 MPa and 3.745 MPa for air curing and oven dry curing respectively. With addition of 1 mol of NaOH, sample with grains size of 1.18 mm produce the highest average compressive strength of 4.364 Mpa and 4.035 MPa for air curing and oven dry curing respectively. In tem of curing method, the cube samples for each grains size which undergo air curing method produced higher strength than sample undergo oven dry method at the age of 28 days.

ABSTRAK

Terdapat banyak faktor yang dapat meningkatkan kekuatan mampatan bagi kiub simen laterit. Contohnya, melalui pengaruh bahan tambahan, nilsbah campuran untuk bahan, saiz butiran aggregat dan sebagainya. Kertas kerja ini membincangkan mengenai kesan kepekatan larutan alkali terhadap kekuatan mampatan kiub simen laterit yang dihasilkan dengan saiz butiran tanah laterit yang berbeza. Selain itu, terdapat dua jenis kaedah pengawetan yang akan diuji iaitu, kaedah pengawetan udara serta kaedah pengawetan pengeringan ketuhar.Projek ini juga bertujuan untuk mencadangkan penghasilan blok dari campuran simen laterit dalam menggantikan blok campuran simen pasir dalam industri pembinaan terutamanya bagi pembinaan bangunan kos rendah atau bangunan luar bandar Untuk penyediaan sampel, tanah laterit yang talah dihancurkan akan ditapis kepada tiga saiz butiran tanah yang berbeza iaitu, 1.18mm, 600 mikro, dan 150 mikro. Kemudian setiap sampel tanah tersebut akan dicampurkan dengan nisbah campuran 1:2:6 (simen: tanah: pasir). Larutan alkali dengan kepekatan 1, 2, dan 3 molar akan dicampur kedalam bancuhan dan kemudian menghasilkan sampel kiub untuk setiap kaedah pengawetan. Bacaan kekuatan mampatan sampel kiub tersebut akan direkodkan pada usia 14 dan 28 hari selepas pengawetan. Kesan dan hubungan di antara butiran saiz tanah, kepekatan larutan alkali dan kaedah pengawetan dapat dilihat dengan jelas. Dapat disimpulkan bahawa, untuk jenis tanah ini, dan nisbah campuran 1:2:6, hanya 1 molar alkali yang disarankan. Penambahan larutan alkali yang lebih pekat akan menyebabkan kekuatan mampatan sampel kiub berkurang. Berdasarkan kesan saiz butiran tanah, sampel kiub terkawal yang dihasilkan dengan tanah bersaiz 600 mikro menghasilkan purata kekuatan mampatan yang tertinggi dengan kekuatan 3.602 MPa untuk kaedah udara dan 3.745 MPa untuk kaedah oven, Manakala, untuk sampel kiub yang dicampur 1 molar NaOH, kiub yang dihasilkan dengan saiz tanah 1.18 mm menghasilkan kiub yang paling kuat iaitu dengan kekuatan 4.364 MPa untuk kaedah udara dan 4.035 untuk kaedah oven. Dari segi kesan kaedah pengawetan pula, sampel kiub yang menjalani kaedah pengawetan udara menghasilkan kiub yang lebih kuat berbanding sampel kiub yang menjalani kaedah pengeringan ketuhar pada usia 28 hari.

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LIST OF ABBREVIATIONS

AASHTO	American Association Of State And Transportation Officials
CIDB	Construction Industry Development Board Malaysia
CLC	Cement Laterized Cube
IBS	Industrialized Building System
LL	Liquid Limit
OPC	Ordinary Portland Cement
NaOH	Sodium Hydroxide
PI	Plasticity Index
PL	Plastic Limit
PWD	Public Work Department

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

In construction industry, cost is considered one of the important elements for constructing a project. Cost in construction includes the initial capital cost, and also the subsequent operation cost and maintenance cost. Generally, running a construction project will involve a lot of budget. Furthermore, the increasing rate of inflation by years, will affect the price of raw materials, transportation, fuel, machinery, man power and others. ot will be a bothers for the clients such as developer to invest money for a project. Hence, to overcome this problem, an alternative material or a new system will be the best option. Construction Industry Development Board Malaysia (CIDB) proposes cost saving methods which are the Industrialized building System (IBS) where the building component or the building systems are pre-fabricated and then install on site. Moreover, it is proven not only reducing the cost but also reduce the construction time.

Further information by CIDB, there is five types of IBS that were introduced for the construction industry to practice which are pre-cast concrete framing, panel and box system, steel formwork system, steel framing system, prefabricated timber framing system and finally the block work system. This report will focus on the block work system or in detail for interlocking block made from cement laterized. The usage of interlocking blocks as the construction materials has been proven to provide a lot of benefits. By implementing the cement laterized interlocking block for buildings will greatly reduce the wastage, volume of building materials, reducing unskilled workers, provide better quality control, promote a safer and more organized site, and last but not least will greatly reduce the construction cost and time (Nasly et al., 2009).

Lateritic soil has been used as a construction material for a thousand years before and by enhancing this material, it can replace some material without dropping the required quality standard and of course reducing the cost. It can be recognized from it well-graded reddish brown state, with sandy-silt clay of medium plasticity and compressibility type of soil. It also has fines content ranging from 27 to 49.5% and contains extremely low gravel percentage of less than 10%. (Elarabi et al., 2013). Hence, this research is in view to recommend the production of blocks from cement laterized in supplementing the conventional sandcrete blocks.

1.2 PROBLEM STATEMENT

Research by Adepegba (1975) indicates that by comparing the properties of conventional concrete with concrete which sand replace by laterite, it shows that, concrete containing laterite could be used for structural member. Besides that, with addition of cement and sand as stabilizer, cement laterized block has a potential to be the alternatives building material which can achieved required strength of 2.8N/mm^2 for non-load bearing wall, 5.2N/mm^2 for load bearing wall and 7.0 N/mm^2 for load bearing wall specified for exterior wall based on the Public Work Department (PWD) standard. With a proper study, the laterite soil can be enhanced and use as one of the material in construction.

There are several factors that affect the mechanical properties of cement laterized block or cube especially in term of compressive strength. Some of the factors are the mix proportion for the block or cube, curing method, soil grains size, presence of additives, water content for the mixture, and many more. Basically, this research were carried out to determine the effect of alkaline solution as additives, effect of grains size and effect of curing method in term of compressive strength of cement laterized cube, (CLC).

1.3 RESEARCH OBJECTIVE

The research will cover on the effect of additives concentration, sodium hydroxide (NaOH) on compressive strength of cement laterized cube (CLC) wwith different soil grains sizes which are 1.18mm, 600 micro and 150 micro. The objectives are as follow:

i. To identify the effect of concentration of alkaline solution (NaOH) on CLC in term of compressive strength.
ii. To determine the relationship between soil grains size and the concentration of alkaline solution in term of compressive strength.
iii. To compare the effect of curing method between air curing method and oven dry method in term of compressive strength.

1.4 SCOPE OF STUDY

i. Laterite soil will undergo mineralogy test, sieve analysis test and atterberg limit test to determine their properties. Then the soil will be sieved through a 1.18mm, 600 micro and 150 micro sieves for sample preparation.
ii. The mixed proportions that will be tested are 1:2:6 (cement: soil: sand).
iii. 8 sets of CLC samples will be produced based on the grains size, alkaline solution concentration and curing method.
iv. Concentrations of NaOH that will be tested are 1, 2 and 3 molarities.
v. The curing methods that the CLC samples will undergo are air curing method and oven dry method.

1.5 SIGNIFICANCE OF STUDY

Based on the current situations, the demands on sands as fine aggregate is high, thus proposing a new potential material which will reduce the cost is one of the options. Using laterite soil as replacement of sand will gives a lot of benefits. The significant of this study are:

i. Proposing the usage of laterite soil as one of the construction material. laterite soil can be easily obtain n in Malaysia and proven by researcher as a potential material to be used in construction.
ii. Recommending the production of block from cement laterized in supplementing sandcrete block which will greatly reduce the usage of cement and sand.
iii. Improvising the cement laterized block to achieve the required strength for multipurpose usage in construction.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Interlocking block system are usually practices for a small low rise building suach as houses and it is known as an effective technique that can reduce cost, and less time consuming compared to the conventional method. Furthermore, the interlocking blocks are different from conventional sandcrete blocks since they do not require mortar to be laid during bricklaying process where it will interlock with each other to to retain load or stress, this research will focus on the usage of laterite soil as the main material in the production of cement laterized blocks or cube.

Using cement laterized materials will give environmental benefits where it can reduce the usage of cement thus decrease the amount of CO_2 emitted and the energy used for construction (Radhi, 2009). The amount of world's cement-carbon-dioxide was recorded at 1 and 1.8 billion tons in years 1988 and 2000 respectively. By considering the trend from cement market and industry production, these CO_2 emissions are expected will reach 3.5 billion by the year 2015 (Davidovits, 2008). The reduction of CO_2 is very important as this harmful gas contributes to global warming through greenhouse effect.

The testing that include in this research are based on the past researches. The test for compressive strength, workability, and water absorption are commonly tested to the block. This section will discuss on the origin and definition of laterite soil and reviews from previous researches that are related with the objectives of this research.

2.2 CEMENT LATERIZED

Generally, cement laterized is an implementation on using both cement and laterite soil as one of the material in construction. This section will discuss about the materials consist in the production of cement laterized materials.

2.2.1 Cement

In construction industry, cement is considered as the most important material especially in production of concrete. Cement will act as stabilizer in the production of cement laterized materials. It cohesive behavior when mixed with water provides binds between aggregates. Thus, with a certain proportion of cement, soil and sand, we can produce a better quality blocks that achieved the required strength state by PWD.

There are many types of cement that are used in construction and it is varies based on their function for the construction. In the production of cement laterized cube, Ordinary Portland Cement (OPC) is selected as a stabilizer.

2.2.2 Laterite Soil

Laterite is a product of tropical or subtropical weathering which occurs abundantly in such regions in South America, Asia, Australia and Africa. The main constituents of laterite soil are oxides of Iron, Aluminum and Silicon. Besides that, it was stated that, laterite is a red tropical soil that rich in iron oxide and usually derived from rock weathering under strongly oxidizing and leaching conditions (Raheem et al., 2012). In Malaysia, laterite soil is easy to find and a cheap raw material. This type of soil has a good thermal and heat insulation value. Furthermore, its capability as a fire resistance when used as a wall structure also give an advantage as a housing construction compared to timber (Raheem et al., 2012).

The stabilizers that usually used for soil in improvement of soil strength are cement and lime. This has been proved in a study by (Raheem et al., 2010) which is cement stabilization involves the addition of small amount of cement while lime stabilization refers to the process of adding burned limestone product in order to improve the laterite soil properties. However, in their study it mentions that cement stabilized blocks is better quality in term of compressive strength, water absorption and durability compared to those stabilized with lime.(Raheem et al., 2010).

Besides that, the most suitable proportion of laterized concrete for structural purposes is by keeping the laterite content below 50 percent of the total fine aggregate (Balogun and Adepegba , 1982)**.**

2.2.3 Water

Generally, clean water is needed in the production of concrete and it includes in the production of cement laterized blocks or cube. Any impurities will affect the mechanical properties of concrete or the mixture. Potable water or other relatively clean water, free from harmful amounts of alkali, acids, or organic matter, may be used. For this project, distilled water was used. Water is necessary for the hydration process of Portland cement and also to help the mixture achieving the maximum compaction.

2.3 ADDITIVES

Additive is a chemical method that can be used to improve the engineering properties of a material. Additives act as stabilizing mechanism. For laterite soil, an alkaline solution was used as additives.

2.3.1 Alkaline Solution

In this study, the distilled water will be added with some proportion of additives which is Sodium Hydroxide (NaOH) to produce alkaline solution. The alkaline solution will be used to determine their effect on mechanical properties of cement laterized cube. These additives will have reaction with clay which will stabilize the soil. Alkaline solution has been proven to give a boost for the cement laterized block in term of their compressive strength. (Rashdan, 2014).

Sodium hydroxide and carbonate was an effective chemical additive for laterite soils stabilized by cement or lime. Besides that, cement, lime, and alkali sodium chemical additives were used to find the optimum combination that produces the best unconfined compressive strength and C.B.R. results. (El-Rawi and Al Samadi, 1995).

2.4 GRAINS SIZE

Grains size is also one of the factors which affecting the compressive strength of cement laterized cube. There is several researches that have proven this statement where most of the result shown an increasing strength for finer soils.

2.4.1 Soil Grains Size

- It was proven that the higher the laterite/cement ratio, the lower the compressive strength. Besides that, the finer the grain size range, the higher the compressive strength. (Lasisi and Ogunjide, 1984)
- Finer grains size has higher cohesive forces that exist between the lateritic particles as the particles get smaller and smaller (Lasisi and Osunade, 1984).

2.5 CURING

Curing is one of the important processes for a mix design sample to go through which can determine their quality and may affect their mechanical properties if not carried out properly. Curing can be defined as a method to maintain moisture on the surface of concrete. It also involves the chemical process between cement and water called hydration which provides the cement adhesive properties to bind the aggregate. With a perfect proportion of water, the mix design sample can achieved their required strength.

2.5.1 Curing Method

From previous study, there are many curing method that are tested by the researcher in production of cement laterized block sample such as, air curing, cured under the shade, cured under the sun and others. For this research, two methods have been selected to be carried out.

- Air Curing
    - Water/air cured specimens gained the greatest strength values at all ages. But the air cured specimens gave the least values at all ages irrespective of the mix proportion. (Falade, 1991)

- Oven dry method.
    - Cured under the sun show a promising result where the compressive strength of the sample applied with this method is higher compared to others. (Wan Abdullah, 2014).
    - For temperature curing (TC), the samples will be wrapped with a plastic membrane preventing moisture loss and then oven cured at 40 °C for 24 hours. Then, the samples will be demoulded and kept in a 23 °C room. (Pangdaeng et al., 2014)

2.6 MECHANICAL PROPERTIES OF CEMENT LATERIZED CUBE

2.6.1 Compressive Strength

The compressive strength of cement laterized block depends on the soil type, type and amount of stabilizer, and the compaction pressure used to form the block. The maximum compressive strengths of the block are obtained by proper mixing of suitable materials and proper compacting and curing. The previous study (Razali, 2013) for the interlocking block using red laterite soils shows that the mix proportions that give the highest value of compressive strength is the 1:2:6 mix proportion of cement-laterite-sand.

The minimum requirement from the Ministry of Work for non-load bearing blocks is 2.8 MN/m2 and for load bearing blocks is 5.2 MN/m^2 (Nasly et al., 2009) and according to the Malaysia Standard MS 7.6: 1972 / British Standard BS 3921: 1985, for General Brick specifications, the average compressive strength for Load Bearing Brick Class 1 is 7.0 MPa.

$f = F/A_c$ [MPa]

Where:

f = compression strength (MPa)

F = ultimate crushing force (N)

A_c = sectional area (mm^2)

2.7 DISCUSSION

From previous research, the optimum mixed design is not determined yet for load bearing wall that is (5.2 N/mm2) and also for (7.0 N/mm2) at exterior part. The most promising mixed design is 1:2:6 of cement, soil and sand which shown higher compressive strength form others mixed design. Besides that, from previous research, by increasing proportion of soil it will reduce the strength of block. Moreover, soil grains size also give effect towards the mechanical properties of CLC Hence, by producing CLC with different grains size, we can determine the best sizes that can produce a high quality CLC with maximum strength. Furthermore, addition of alkaline solution in the mixture shows that it will produce a stronger laterized interlocking blocks in term of compressive strength. Thus, by increasing the concentration of alkaline solution we can determine the optimum additives concentration and the suitable grains size as the solution to improve the mechanical properties of cement laterized cube. Curing method is also one of the factors that can improve mechanical properties of the CLC.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter reports on clear insight to the study as well as the methodology that will be implement for this research. The materials, method to produce cement laterized cube, procedure for testing, data collection method and machineries involves in this research are describe in detail in this section.

3.2 RESEARCH MATEERIALS

This section will mainly focus on the preparation of raw materials needed to produce the cement laterized cube and the instrument used for this research. The raw materials include Ordinary Portland Cement (OPC), laterite soil, alkaline solution and fine sand.

- ***Ordinary Portland Cement***

There are varieties of Portland cement available in the market. In this study, Ordinary Portland Cement is chosen to be used in producing the sample due to their economical value and widely used in construction industry.

Figure 3.1: Ordinary Portland Cement

- ***Laterite Soil***

The laterite soils were obtained from Kerteh, Terengganu. Before undergo mixing process, the soil will be crushed and sieved through a 1.18mm, 600 micro and 150 micro. Each size will be used to produce sets of cubes with addition of different concentration of alkaline solution.

Figure 3.2: Laterite soil